I. C. 6744 SEPTEMBER, 1933

UNITED STATES BUREAU OF MINES
SCOTT TURNER, DIRECTOR

INFORMATION CIRCULAR

METHODS AND COSTS AT THE GRANITE QUARRY AND CRUSHED-STONE PLANT OF THE WESTON & BROOKER CO., CAYCE, S. C.

BY

T. I. WESTON

I.C. 6744
September, 1933.

INFORMATION CIRCULAR

UNITED STATES BUREAU OF MINES

METHODS AND COSTS AT THE GRANITE QUARRY AND CRUSHED-STONE PLANT OF THE WESTON & BROOKER CO., CAYCE, S. C.[1]

By T. I. Weston[2]

This is one of a series of papers being prepared for and published by the United States Bureau of Mines, describing mining and milling methods and costs at crushed-stone plants throughout the United States. These papers are designed to disseminate technical information regarding the methods used. The cost tabulations represent operating expenditures only and not total production costs. It is recognized that publication of total production costs might in many instances cause embarrassment to individual producers, as well as to the industry as a whole. However, operating costs are essential to the technical discussion and study of the methods employed. The attention of the reader is specifically called to this differentiation in order that no misunderstanding of the scope of the cost tabulations shall ensue.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance of F. W. Horton, mining engineer, United States Bureau of Mines, in the preparation of this paper.

LOCATION OF PROPERTY

The quarry described in this paper is situated on the south bank of the Congaree River at Cayce, 3 miles from Columbia, S. C. It is on the main line of the Seaboard Air Line Railway and but a few hundred yards from the main line of the Southern Railway. Having other railway connections at Columbia, it is well located to obtain a wide distribution of its products by rail.

---

[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6744."

[2] One of the consulting engineers, U. S. Bureau of Mines, and president, Weston & Brooker Co.

HISTORY

The quarry has been in operation for more than 40 years, but it was not until 1908 that crushing equipment was installed. This first mill was run by steam and had a daily capacity of 600 tons. The plant and the quarry were purchased from R. G. Ross in 1912 by the present owners. In order to increase capacity and to cut costs, the crushing plant was rebuilt in 1916, electrified throughout, and a larger crusher installed. In August 1926 a fire destroyed the mill, but it was rebuilt immediately, and the new plant (with capacity increased to 1,500 tons daily) was in successful operation in November of the same year--less than 4 months after the fire.

GEOLOGY

The quarry is in flat country about 2 miles south of the fall line of the Piedmont Plateau, in an area of crystalline rocks. The general surface level is about 40 to 50 feet above the Congaree River. The quarry rock is a gray, fine- to coarse-grained biotite granite which underlies a recoverable area of about 75 acres and is possibly a part of the same granite mass which is exposed in the old quarries almost directly across the Congaree River. The granite is covered by an overburden of rotten granite and clay ranging from 1 to 30 feet in depth and averaging perhaps 10 to 12 feet.

Two systems of joints are developed in the granite--one nearly horizontal and one roughly vertical--but with wide variation in spacing, which seems to average closer at the surface than at the quarry floor 200 feet below. The jointing gives considerable trouble in both drilling and blasting. The granite contains few or no inclusions of other rock.

PHYSICAL CHARACTERISTICS AND CHEMICAL COMPOSITION

The following results were obtained from physical tests made on the granite by the Bureau of Public Roads of the United States Department of Agriculture:

Specific gravity		2.62
Weight per cubic foot	pounds	163
Weight of water absorbed per cubic foot	percent	0.31
Percent of wear		2.5
French coefficient of wear		16.0
Hardness		18.3
Toughness		13
Crushing strength	pounds per square inch	33,090

The excellent physical characteristics of the rock enable it to meet the most exacting specifications. Chemically it shows but slight variation, as is illustrated by the two following analyses:

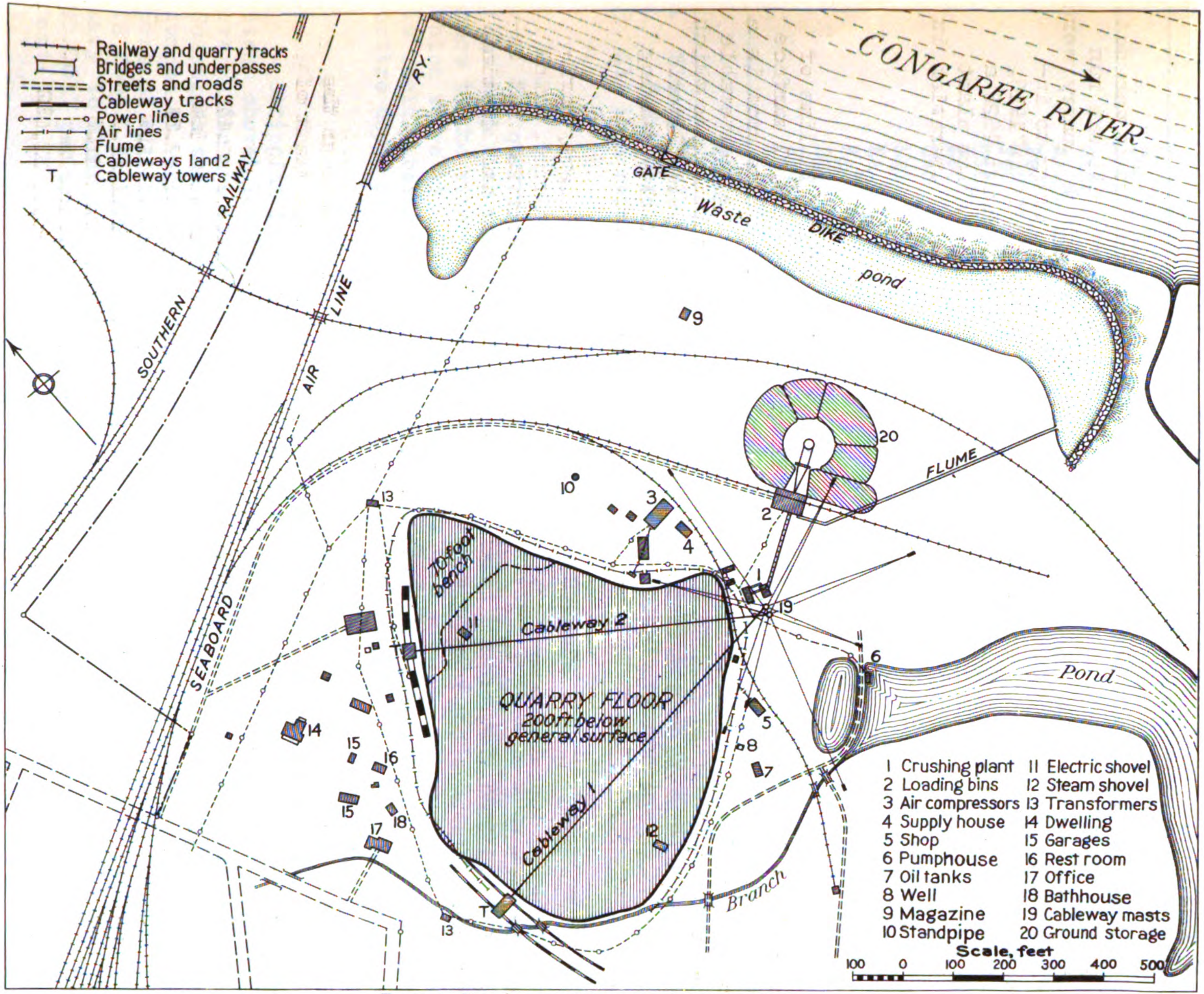


Figure 1.—Sketch map of Cayce quarry and vicinity.

Chemical analyses of Cayse granite

Constituents	I[1]	II
SiO_2	72.19	72.28
Al_2O_3	14.06	14.29
Fe_2O_3	.70	2.37
FeO	1.80	(2)
TiO_2	.48	.30
MnO	.16	-
CaO	1.88	1.88
MgO	.84	.40
Na_2O	3.46	3.69
K_2O	3.94	4.05
SO_3	Trace	Trace
P_2O_5	Trace	-
Loss on ignition	.18	.71
Total	99.69	99.97

1 Sloan, Earle, Catalogue of the Mineral Localities of South Carolina: Bull. South Carolina Geol. Survey, ser. IV, No. 2, 1908, p. 253.

2 All iron reported as Fe_2O_3.

GENERAL DESCRIPTION OF PIT

The quarry is a pit about 900 by 800 feet in plan and approximately 200 feet deep with nearly vertical sides. Figure 1 shows its location with reference to the river and nearby railroads and a plan of the cableways and plant which serve it. With the exception of a 70-foot bench at the north end which is rapidly being worked out, the pit is mined without benching by blasting the entire depth of its 200-foot face.

STRIPPING

Stripping is done intermittently with a ¾-yard, full-circle, caterpillar steam shovel loading directly into 2-ton trucks. Approximately 700 tons of overburden are stripped per day, and the average haul is about 800 feet. Sometimes the overburden is sold as fill, but as a rule it is wasted and dumped at various points on the property where it will serve some useful purpose or will be out of the way. The average depth of the overburden is 10 to 12 feet. In 1929, about 4 acres were stripped, and it has not yet been necessary to clear more ground. Stripping costs 25 cents per cubic yard, or $0.0017 per ton of stone uncovered, based on the present quarry depth of 200 feet.

PRIMARY DRILLING

Primary drilling is done by four churn drills, each operated by a 25-hp., 550-volt, a.c. electric motor. On the benches the drill holes are 6 inches in diameter, spaced 25 feet between centers and 18 feet from the face, and drilled 1 foot below the quarry floor. When the full quarry face is to be shot, the holes are spaced 20 feet between centers and the same distance from the face and are sunk 10 feet below the quarry floor. Regulation chisel bits are used. For drilling bench holes the bits are hand-sharpened, but for deep holes they are sharpened by machine because machine-sharpened bits are better for long holes in seamy rock and drill a hole of more regular shape. The normal string of tools weighs 1,070 pounds, divided as follows: Bit, 240 pounds; stem, 800 pounds; and rope socket, 30 pounds. The drills make fifty 35-inch strokes per minute, and the sludge is pumped about every hour. The bits are used 2 to 4 hours before they are removed for sharpening. A wooden platform on which a 4-foot length of casing is mounted acts as a guide in starting holes. The average rate of drilling is about 7½ feet in 10 hours, although a depth of as much as 20 feet is sometimes obtained in that time. Cracks or seams in the granite occasionally cause trouble in drilling, in which case scrap wrought iron (old chain, etc.) is thrown into the hole and beaten into the cracks with the drill. If this treatment fails the bad section of the hole is filled with cement, which is drilled out after it has set firmly.

SECONDARY DRILLING

Secondary drilling is done with 12 jackhammers using 7/8-inch solid steel for holes up to 6 feet deep and 2 tripod drills with 1¼-inch hollow steel for wet drilling holes 6 to 20 feet deep. Compressed air is supplied from branch lines leading down the face of the quarry from a main air line which nearly encircles the pit at the surface. (See fig. 1) The air pressure at the compressors is 110 pounds per square inch, which gives a working pressure of about 85 pounds at the drills. All rock weighing more than one half ton, which amounts to 25 to 30 percent of the total, is blockholed.

Jackhammer drillers are paid 2 cents per hole drilled. An initial 8 inches is accounted one hole, and each 4 inches of additional depth is credited as another hole. Thus a hole 12 inches deep is credited as two holes. Jackhammer drillers average 500 to 700 holes per week. Tripod drillers are paid 20 cents per hour.

BLASTING

Figures 2 and 3 show loading diagrams for various bench and full-face holes. Gelatin dynamites of 60 and 75 percent strength are used in sticks 16 inches long and 4½ inches in diameter. The stronger dynamite is employed only in the bottom of the holes and averages about 25 percent of the total used in primary blasting. The holes are not sprung.

Double-countered cordeau is used for detonation and is connected with a main lead of uncountered cordeau which is fired by a No. 6 detonator by means

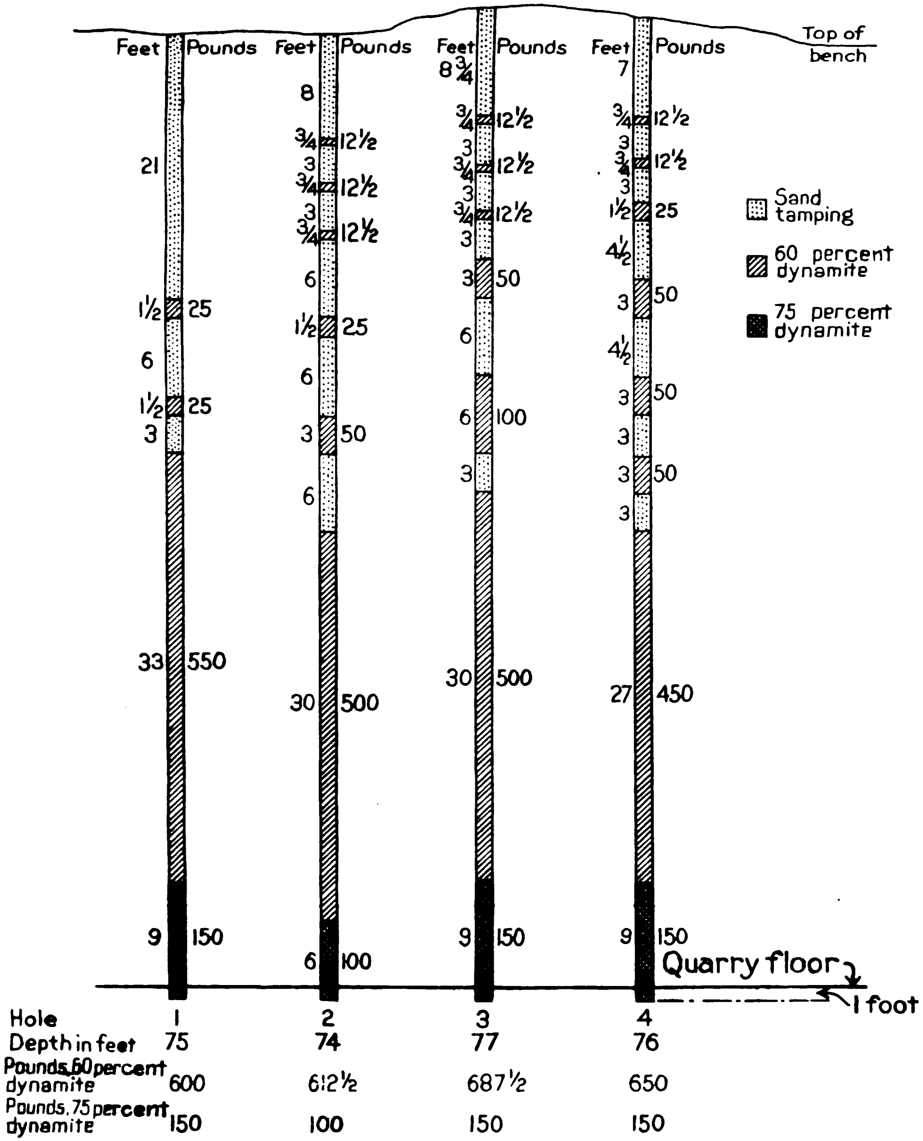


Figure 2.—Loading diagrams of bench holes.

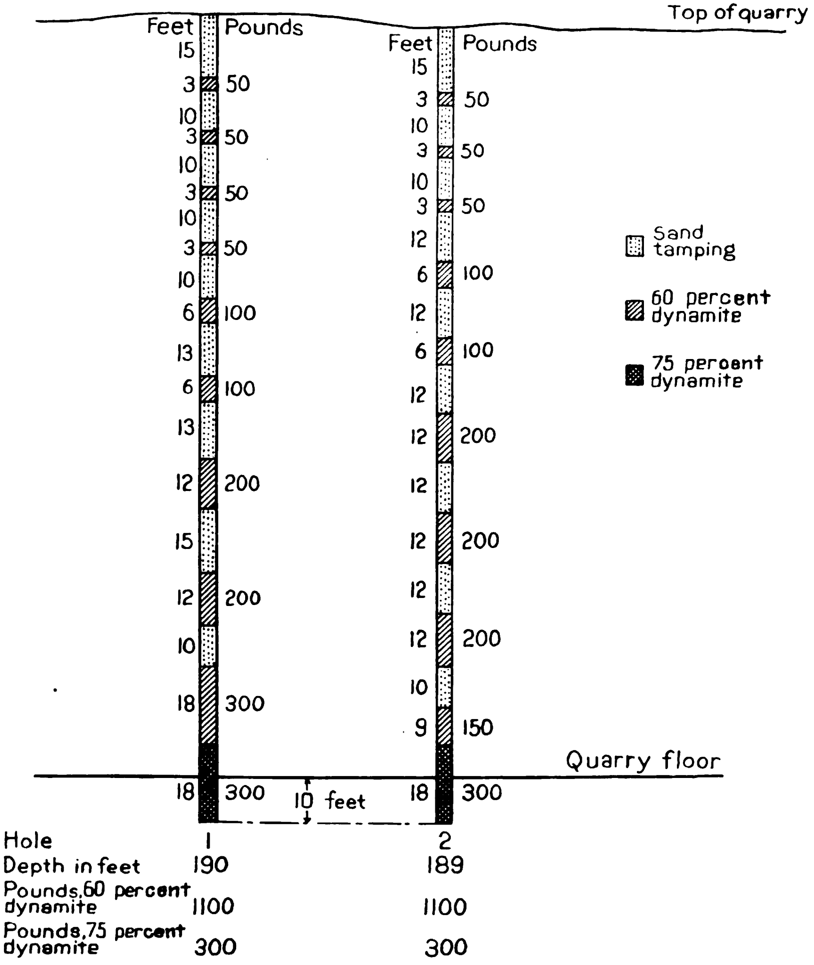


Figure 3.—Loading diagrams of deep holes used in blasting entire height of quarry face.

of a hand-operated magneto. Loading is done by a crew of six men; 1 man opens the boxes, 1 man loads powder, 1 man loads sand tamping, and 3 men tamp. The first 200 to 300 pounds of dynamite are lowered into each hole, and the rest is dropped in. A timber billet 5 inches in diameter and 5 feet long loaded with lead and weighing 100 pounds is used as a tamping block. From 45 minutes to an hour is required to load a 75-foot hole. From 3 to 12 holes are fired at a time.

A considerable variation will be noted in the loading of the four holes shown in figure 2. In hole 1 much of the burden at the top was pulled by a previous shot, but the toe was unusually heavy. In hole 2 the burden was fairly even, but seams and deep cracks along the bottom indicated that the usual 150-pound charge of 75-percent dynamite could be reduced. Holes 3 and 4 show loadings under normal conditions where the burden is solid and of uniform depth.

Spaced 25 feet between centers and with a burden of 18 feet, the four bench holes shown, using 3,100 pounds of dynamite, broke 123,300 cubic feet or 10,000 tons of rock--a ratio of 3¼ tons per pound of explosive.

In figure 3, which illustrates the loading of full-face or deep holes, the charges in the two holes are staggered insofar as practicable to bring the explosive in one hole opposite tamping in the adjoining one. These deep holes are carried 10 feet below the quarry floor instead of only 1 foot, as with bench holes. Spaced 20 feet between centers and with a 20-foot burden, the two holes shown, using 2,800 pounds of dynamite, broke 11,750 tons of rock (4.2 tons per pound of explosive). Thus in the deep holes the rock broken per pound of explosive is about 30 percent more than in the shallower bench holes and equally good fragmentation is obtained because of closer spacing. On account of the large increase in the duty of the explosive when used in deep holes, benching will be abandoned as soon as the bench at the north end of the quarry is worked back to the quarry face.

There are no adobe shots. All holes are loaded and tamped with sand by a crew of two men. Forty-percent gelatin dynamite in 1- by 8-inch sticks is fired by No. 6 detonators and safety fuse with a burning rate of 1 foot in 40 seconds. Approximately 125 pounds of dynamite per day are used in secondary blasting, and about 1,250 tons of rock are loaded per day; the duty obtained, therefore, is equal to 10 tons of rock per pound of explosive. Secondary shots are fired at noon and at 6 p.m.

LOADING

Two full-swing caterpillar shovels, one a No. 32 steam shovel with a 1¾-yard dipper and the other a No. 50B electric shovel with a 2-yard dipper, load the broken rock. Coal for the steam shovel is lowered into the pit in a rock skip, and water is brought down over the quarry face from a concrete standpipe 4 feet in diameter and 20 feet high, on the surface. Three-phase, 550-volt alternating current is supplied to the electric shovel through a rubber cable laid on the quarry floor from a line carried over the edge of the quarry on poles. The electric shovel takes the brunt of the work and loads about 750 tons per day compared with 500 tons handled by the steam shovel. The shovels load into 6- by 9½-foot steel skips 2 feet deep, which hold an average of 6 tons of rock each.

TRANSPORTATION

The loaded rock is hoisted from the pit and conveyed to the primary crusher by means of two movable cableways swung from stationary masts at the discharge end near the crusher. One mast is 35 feet and the other 60 feet high. The opposite end of each cableway across the pit is attached to a movable tower running on a track with a radius of curvature equal to the length of the cableway. The arrangement of these cableways is shown in figure 1. Cableway 1 is about 900 feet long, and its tower is supported by standard railroad trucks running on two standard-gage concentric tracks, 37.5 feet between centers, which the tower bridges. Cableway 2 is 800 feet long, and its tower runs on a single track of 8½-foot gage that is banked at 8° against the pull of the cable. The main or track cables are 2¼ inches in diameter and are made of single-strand, 91-wire plow steel. Each tower is equipped with an electric hoist for conveying, one for hoisting and one for dumping the skips. All running cables are of ¾-inch diameter and are made of 6-strand, 19-wire, special steel.

As the hoistman cannot see the skips when they are well down in the pit or on the quarry floor, he is signaled by a flagman stationed near the discharge end of the cableway where the skips are in plain sight at all times.

An interesting feature of the cableway operation is the use of eight-wheel compensating cable carriages, designed and built by the company, that automatically adjust themselves to the constantly varying curvature of the track cables as the skips travel back and forth. Use of these carriages prolongs the life of the track cables considerably by eliminating sharp bends and by distributing the load over eight points. A sketch of one of these carriages and its rigging is shown in figure 4.

The load on a main cable is made up as follows:

	Weight, pounds
Carriage	2,500
Skip	4,412
Blocks	1,506
Chains	272
Main fall and dumping line	760
Total dead load	9,450
Live load (rock)	12,000
Total load	21,450

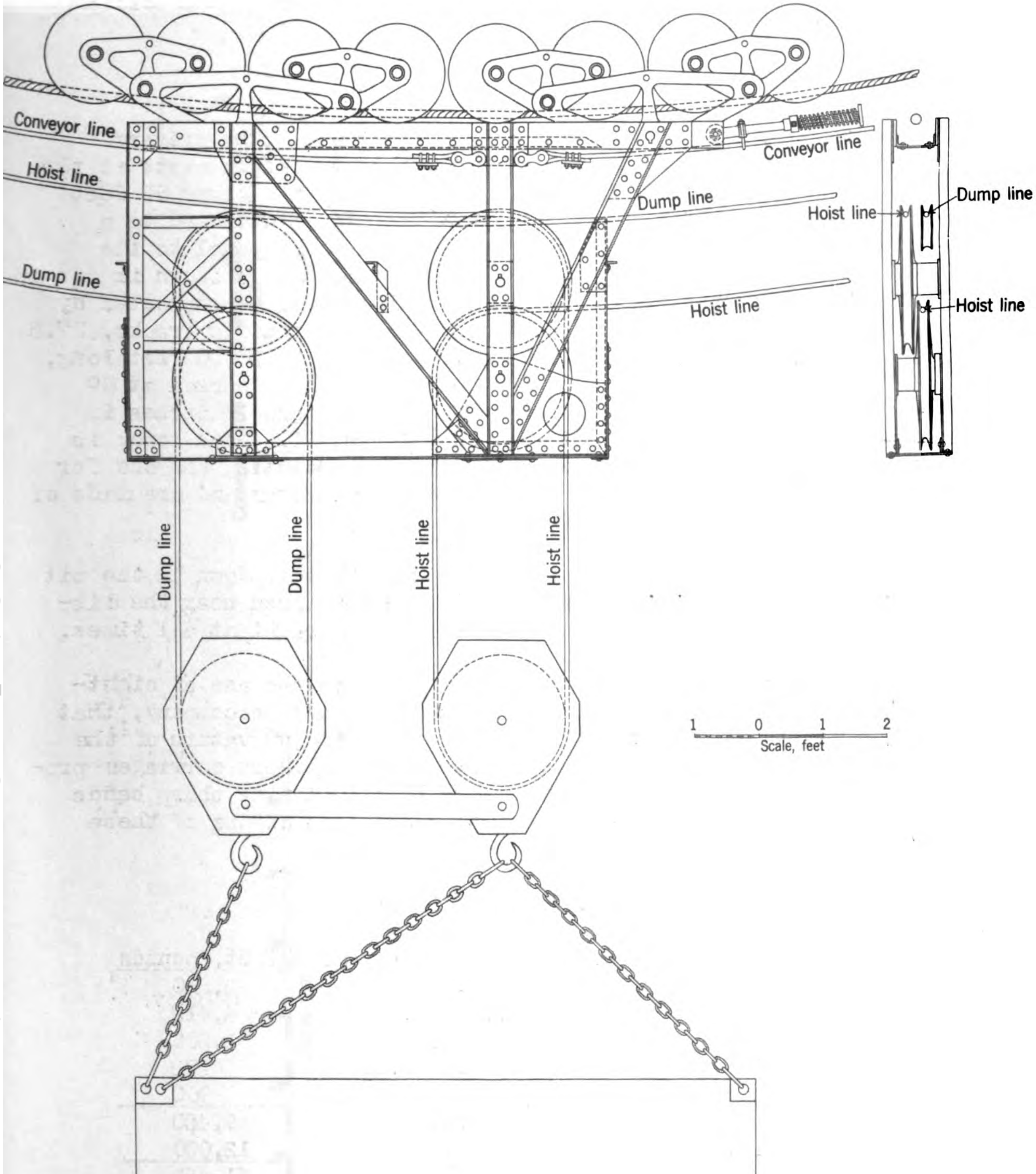


Figure 4.–Compensating cable carriage and skip.

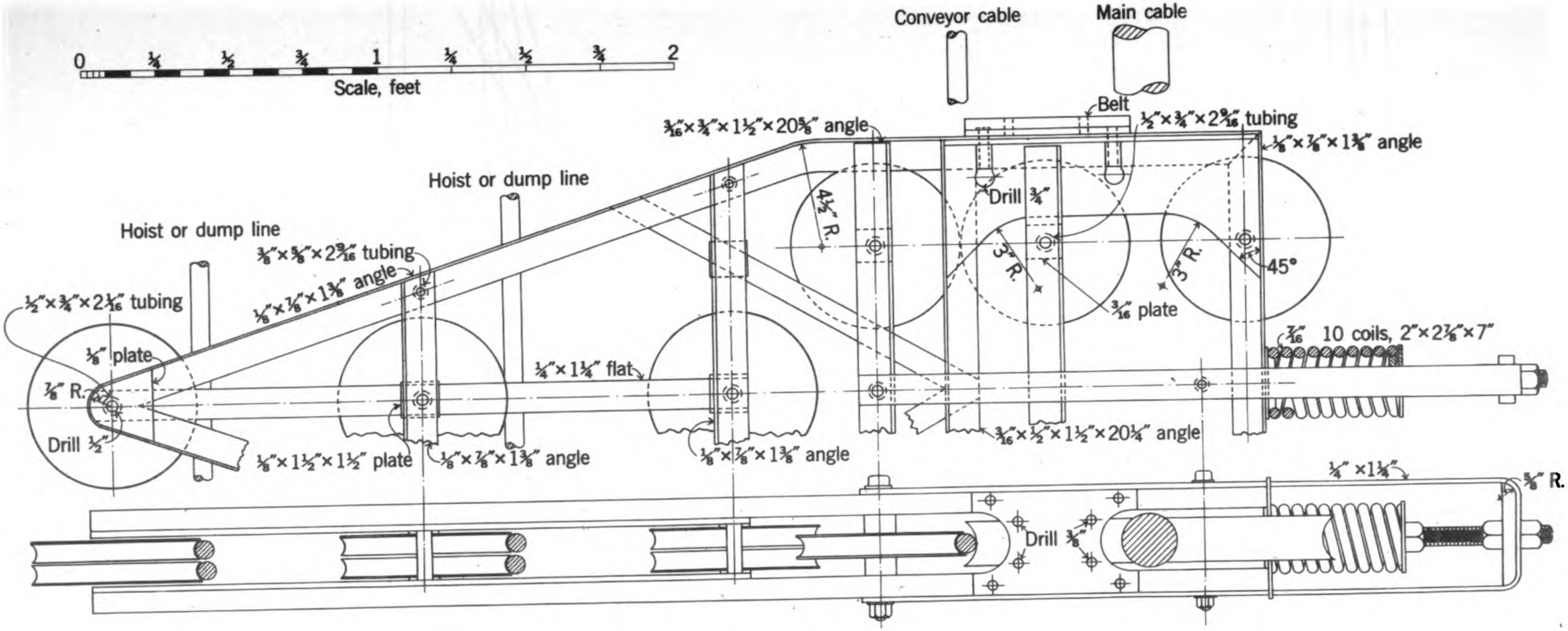


Figure 5.–Sections of ½-speed spacer carriage.

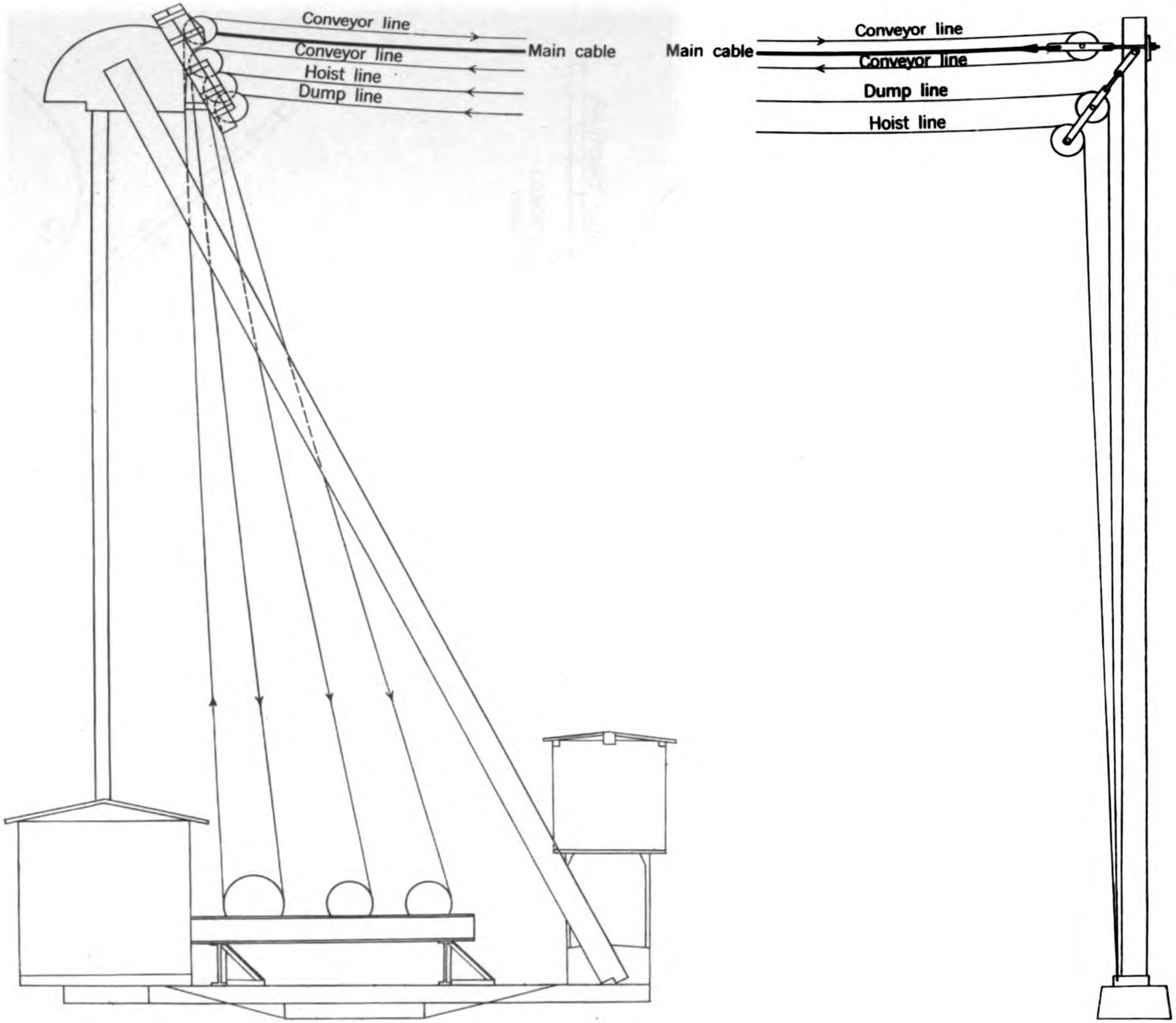


Figure 6.—Schematic diagram of cableway tower and rigging.

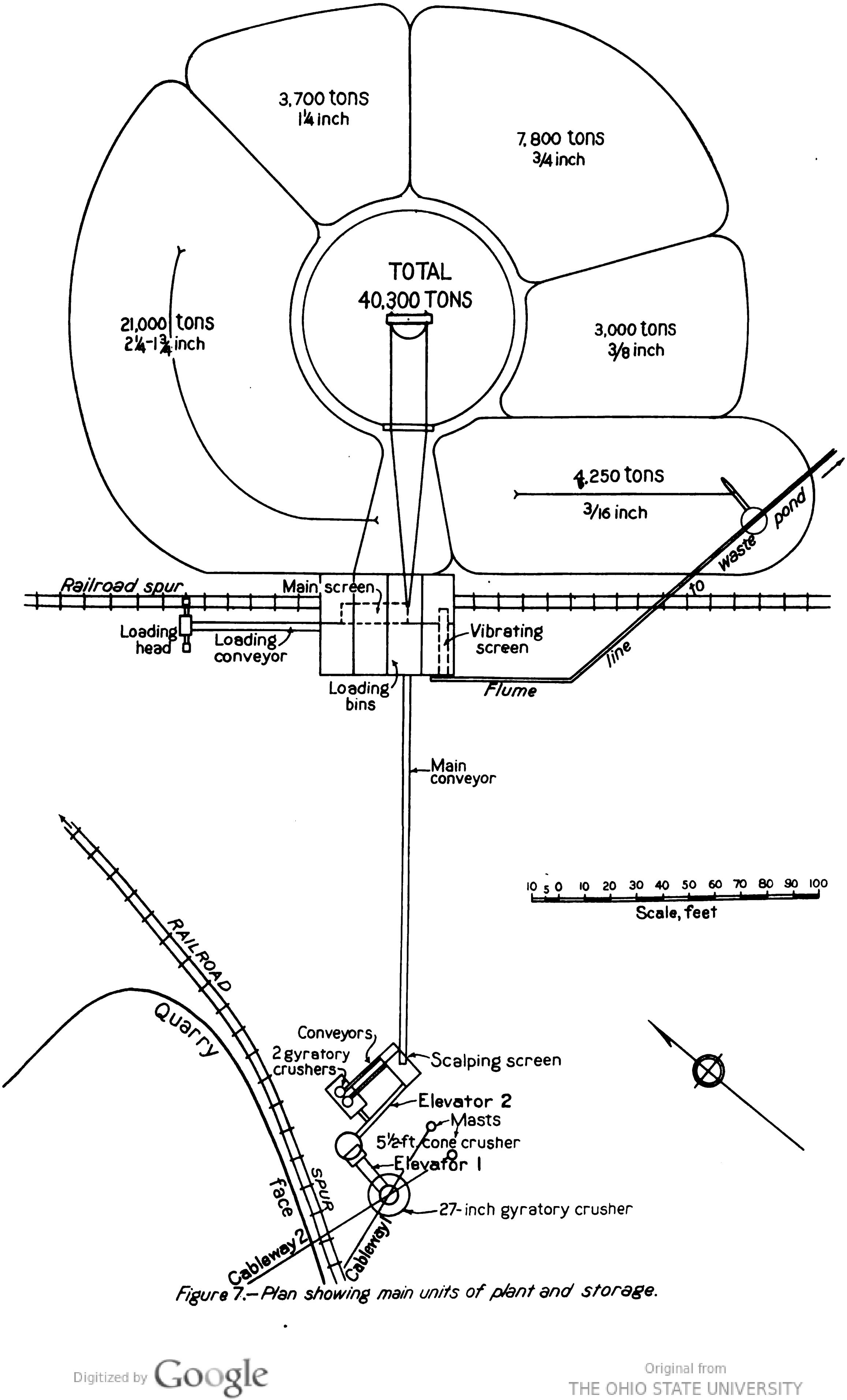


Figure 7.—Plan showing main units of plant and storage.

A spacer carriage which supports the hoist, conveying, and dump lines is placed between the skip carriage and each tower. The spacers travel at one half the speed of the main carriage and are therefore always half-way between the main carriage and the end of the cable. Figure 5 shows sections of this $\frac{1}{2}$-speed spacer.

Figure 6 is a schematic diagram showing a section of the tower of cableway 1, the rigging of the various hoists and sheaves, the method of attaching the main cable to the mast, and the bridle fastening of the dump and hoist lines. The latter fastening reduces sudden strains on the mast and the lines and converts part of the direct pull into a compressive strain in the mast.

Rope speeds for the cableways are as follows:

	Speed, feet per minute	
	Cableway 1	Cableway 2
Hoisting line	127½	125
Dumping line	275	250
Conveyor line	720	900

Figure 7 shows a plan of the plant, the position of the principal crushing and sizing units, and bin and ground storage.

CRUSHING AND SIZING

The loaded rock skips are dumped directly into a 27-inch gyratory crusher with a discharge opening of 6 inches. This crusher is belt-driven at 290 r.p.m. from a 150-hp. motor. The discharge from the crusher is raised by a 40-inch inclined close-connected chain and bucket elevator (No. 1) to a grizzly made from $\frac{3}{4}$-inch manganese-steel plates with a $37\frac{1}{2}^{\circ}$ slope and $2\frac{3}{4}$-inch round openings. This grizzly has 4 panels, each 30 inches by 4 feet, and is 5 by 8 feet over all. The elevator has a slope of 60° and is 43 feet 8 inches long. It carries 60 manganese-steel buckets on 240 links held together by chrome-nickel steel pins. Each bucket is 40 inches wide, of triangular cross-section, and 1 foot deep. The elevator is driven 180 f.p.m. by a 30-hp., 800-r.p.m. motor.

The oversize from the grizzly is discharged to a $5\frac{1}{2}$-foot cone crusher with an opening of $1\frac{1}{4}$ inches and driven at 490 r.p.m. by a 150-hp. motor. The discharge from the cone crusher joins the undersize from the grizzly and is raised by elevator 2 to the head of the scalping screen. Elevator 2 has a vertical height of 38 feet between centers and a horizontal length of 23 feet. It is of the sprocket-and-double-chain type and carries 50 carbon-steel buckets, each of which is 30 inches wide and of triangular cross-section, 18 inches on the chain and $10\frac{1}{2}$ inches deep. This elevator is driven 180 f.p.m. by a 30-hp., 900-r.p.m. motor.

The scalping screen is a cylindrical trommel 84 inches in diameter and 12 feet long, set on a slope of 1¼ inches to a foot and lined with 9/16-inch, high-carbon steel plate punched with 2½-inch round openings. It is driven at 13 r.p.m. by a 30-hp., 900-r.p.m. motor. The oversize from the scalping screen, amounting to about 25 percent of the feed, is carried on a 5-ply, 24-inch rubber conveyor belt, 36 feet between centers, with a 1/8-inch top cover, a 1/32-inch bottom cover, and a slope of 17°, to two gyratory crushers set with an opening of 1¼ inches. These crushers, which were designed and built by the company, are driven at 400 r.p.m. by two 75-hp., 400-r.p.m., squirrel-cage motors. The discharge from the crushers is chuted to elevator 2, which returns it to the scalping screen. The undersize from the scalping screen, amounting to about 75 percent of its feed, drops to the main conveyor belt, which takes it to the sizing screen. This conveyor is a 5-ply, 32-ounce duck, 30-inch rubber belt with a 1/8-inch top and 1/16-inch bottom cover. It has a horizontal length of 168 feet between centers, a vertical height of 55 feet, and is driven 260 f.p.m. by a 20-hp., 720-r.p.m. motor.

The main screen is a 60-inch by 40-foot trunnion-type trommel set on a slope of 1¼ inches to a foot. The screens in the trommel are made of ¼-inch steel plate punched with round holes of 2-, 1½-, 1-, and ¾-inch diameter in the various 4-foot sections. The jacket, 80 inches by 21 feet, is also made of 5/16-inch steel plate and has 7/16-inch round punched holes. The trommel is driven 16 r.p.m. by a 20-hp., 720-r.p.m. motor. It uses about 1,200 gallons of water per minute, which is discharged through a series of sprays inside the trommel. All wash water is supplied through two 400-foot lines of 6-inch pipe by two 30-hp. electrically driven pumps which are rated at 1,440 gallons per minute against a vertical head of 100 feet. The sizing screen makes five sizes of washed stone that are chuted to bins directly below. These sizes are:

Size, inches

Minus 2½ plus 2
Minus 2 plus 1½
Minus 1½ plus 1
Minus 1 plus ¾
Minus ¾ plus 3/8

The undersize from the sand jacket is flumed to two vibrating screens of 3/32-inch rustless chrome steel with 3/16-inch round openings. The oversize drops to the bins. The vibrating screens are 18 inches wide and 7 feet long and have a slope of 7½°. They are driven by two off-center fly-wheel mechanisms operated by a 7½-hp. motor and make 1,050 five-sixteenth-inch throws per minute. The direction of throw is 75° with the horizontal. The vibrating screens are provided with washing sprays which discharge 200 gallons of water per minute. Their oversize is chuted to a bin below and makes a sixth size of commercial product. The undersize is flumed to the waste pond. (See fig. 1.) Figure 8 shows a complete flow sheet of the plant.

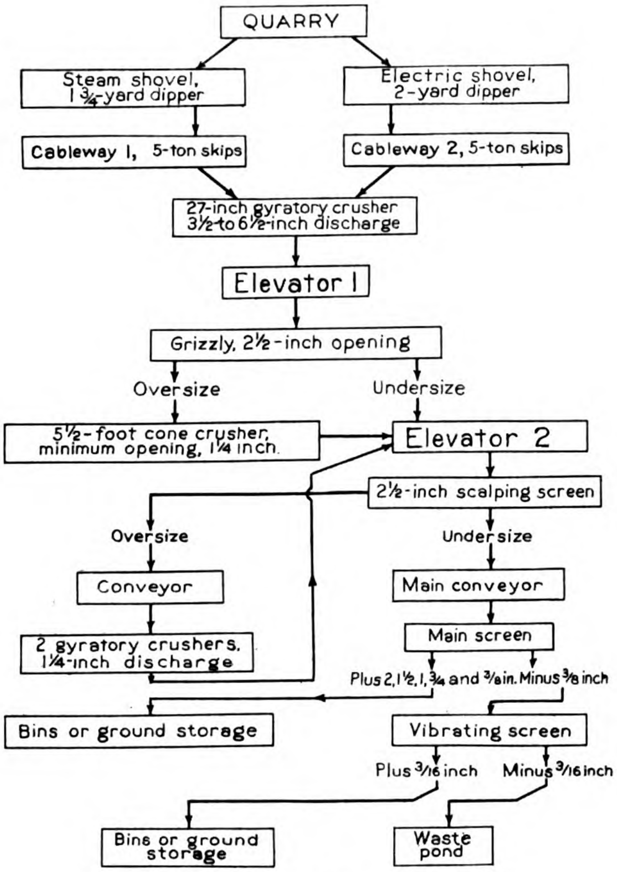
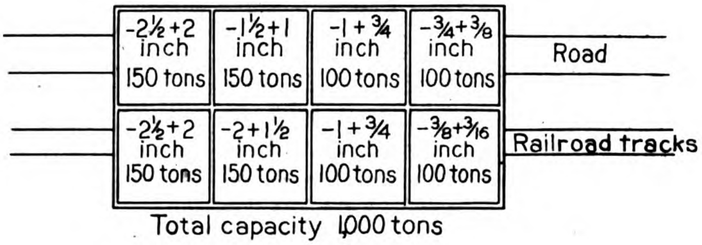


Figure 8.–Flow sheet.



-2½+2 inch 150 tons	-1½+1 inch 150 tons	-1+¾ inch 100 tons	-¾+⅜ inch 100 tons
-2½+2 inch 150 tons	-2+1½ inch 150 tons	-1+¾ inch 100 tons	-⅜+3/16 inch 100 tons

Total capacity 1,000 tons

Figure 9.–Plan of loading bins, showing sizes and capacities.

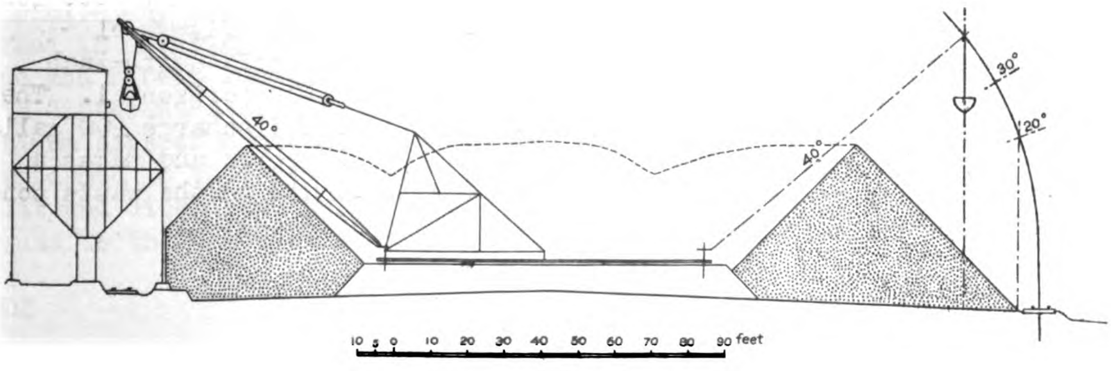


Figure 10.–Section through bin and ground storage.

STORAGE

The loading bins of steel and concrete are hopper-bottomed and have a combined capacity of 1,000 tons. They are directly underneath the floor supporting the sizing screen and are high enough above the ground to allow the passage of railroad cars and trucks beneath them. Hence, the sized and washed stone drops by gravity from the screen to the bins, and from the bins via a conveyor to cars or directly to trucks. A plan of the loading bins with the capacity of the eight divisions and the size of stone carried in each is shown in figure 9.

Stone for ground storage is transferred from the loading bins by an electric crane mounted on a circular base 90 feet in diameter. The crane has a two-drum hoist, a 90-foot boom, and a $2\frac{1}{2}$-yard clamshell bucket and is powered by a 90-hp. motor. Stone is deposited according to size in one of five piles, as shown in figure 7. With the boom at an angle of 20° the bucket has a clean-up swing 257 feet in diameter. A cross-section of the loading bins, crane, and ground storage is shown in figure 10 and a plan of the storage in figure 7. With the various sizes piled as shown, the storage capacity served by the revolving crane is 40,000 tons. Whenever required ground storage may be increased by means of a 60-hp. gasoline caterpillar crane with a $\frac{1}{2}$-yard clamshell bucket which removes stone from the piles built by the revolving crane and transfers it to others.

SHIPPING

In loading stone from ground storage it is picked up by the clamshell of the revolving crane and returned to the loading bin. Hand-operated gates in the bottom of this bin allow the material to drop onto a conveyor belt parallel with the long axis of the bin which discharges it into trucks or railroad cars. This conveyor is 113 feet 10 inches horizontally and 27 feet 5 inches vertically between centers. It is driven at a rate of 300 f.p.m. by a 20-hp. 900-r.p.m. motor and has a 30-inch, 5-ply canvas belt with a 1/8-inch rubber top and a 1/16-inch rubber bottom.

Where customers' specifications require mixed sizes of stone the loading conveyor receives material from two or more bins and discharges it into a loading head where it is cascaded from three shelves to mix it thoroughly. If it is to be delivered by truck it is chuted to a 50-ton bin, but if it is for railroad delivery it is discharged over a stationary plate screen in the loading head, where it is sprayed with 300 gallons of water per minute to eliminate any dust that has accumulated in storage or fines that have been formed in handling. This washing screen has a slope of $32\frac{1}{2}$°, is 30 inches wide and 8 feet long, and is punched with round holes. Interchangeable plates with different-size holes (usually 3/16-inch) are used, depending on the minimum size of material to be retained. The water, dust, and other fines are flumed to the waste pond. The oversize falls into a box, where it is split and discharged by two crosschutes into a carriage traveling at right angles to the conveyor which remixes the stone and distributes it over the width of a railroad car below. A section of the loading head showing the plate screen and traveling carriage for loading the mixed stone is shown in figure 11. The carriage is suspended from a truck running on channel irons as shown and is actuated by a rope running over pulleys from the drum of a reversible air motor. This mechanism pulls the carriage back and forth across the car while an electric hoist at the side of the track pulls the car slowly ahead. In this way the whole car is evenly loaded without segregation of the various sizes comprising the mixed stone.

POWER

All machinery in the quarry and plant is operated by electricity, with the single exception of a steam shovel. Electric current at 13,000 volts is purchased from the Broad River Power Co. and reduced at various transformer stations on the property to 550 volts. Power costs $0.0135 per kilowatt-hour for the first 100,000 kw.-hr. and $0.01 per kilowatt-hour for the overage. About 175,000 to 200,000 kw.-hr. are used per month. The principal power lines on the property are shown in figure 1.

COMPRESSED AIR

About 1,300 cubic feet of compressed air per minute are furnished for secondary drilling and miscellaneous purposes by two motor-driven 2-stage air compressors which deliver air to their receivers at 110 pounds per square inch pressure. One compressor is belt-driven at 600 r.p.m. by a 150-hp. slip-ring motor and the other at 240 r.p.m. direct by a 250-hp. synchronous motor. The capacities of these compressors are 600 cubic feet and 1,350 cubic feet per minute, respectively. A 4-inch air line 2,000 feet long almost encircles the quarry at the surface (see fig. 1) and is tapped at convenient points by 2-inch lines carrying the air to the drills on the quarry floor, where it has a terminal pressure of about 85 pounds per square inch.

DRAINAGE

Although the floor of the quarry is about 140 feet below the level of the Congaree River there is little subsoil drainage into the pit. A 40-hp., two-stage, centrifugal electric pump rated at 500 gallons per minute operating only 3 or 4 hours per day lifts the pit water from a sump at one side of the quarry to the surface through 5-inch special tubing in a 6-inch drill hole and discharges it into a pond at the surface. This pump operates against a vertical head of about 200 feet plus a 40-foot friction head.

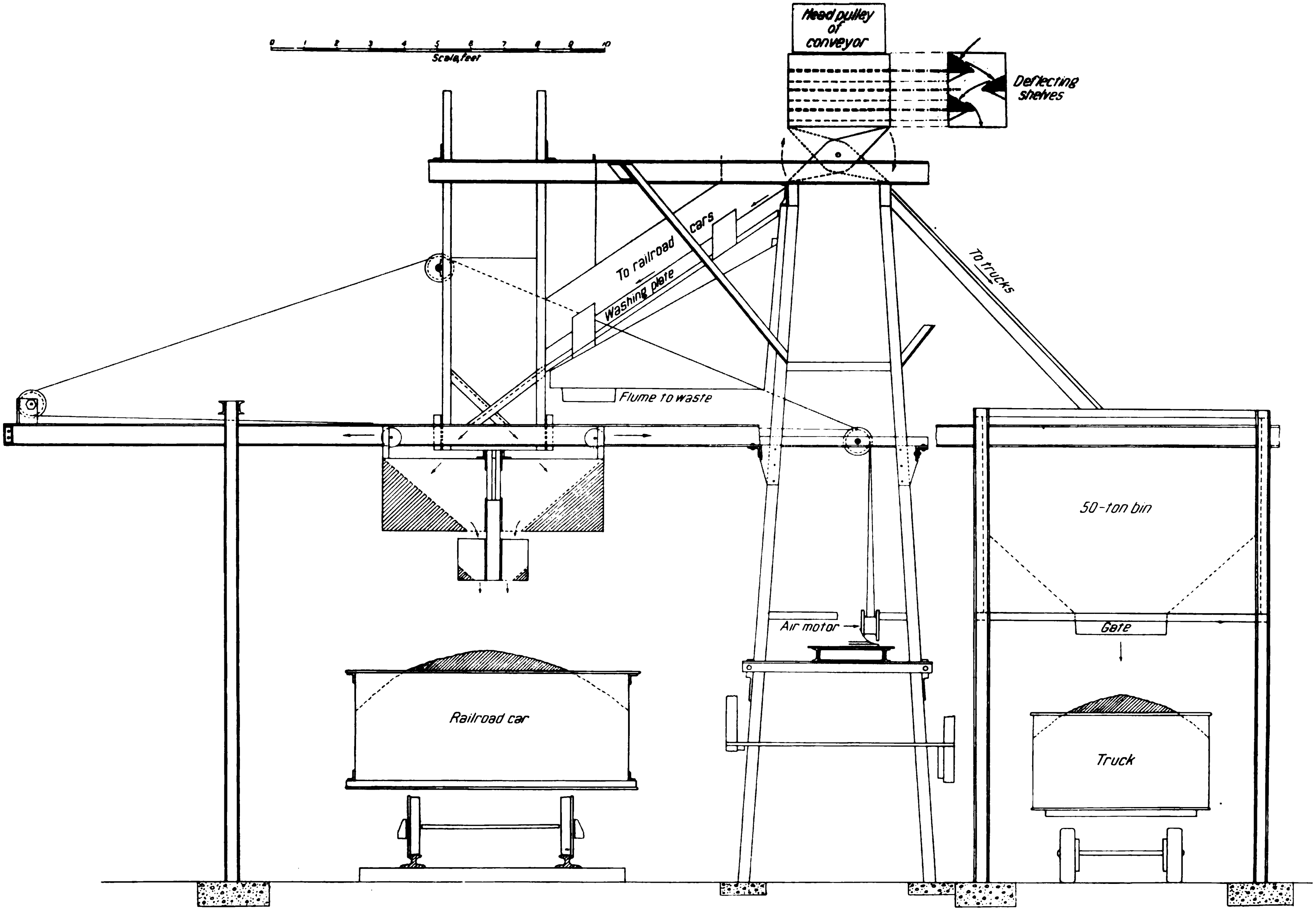


Figure 11.—Section of loading head and carriage.

RECOVERY

About 85 percent of the rock quarried is sold and 15 percent is wasted as fines less than 3/16 inch in size. About 2 percent of the total is sold as large blocks for jetty works and 3 percent as riprap. Of the 80 percent sold as crushed stone the proportions of the various sizes are as follows:

Size, inches	Percent
Minus $2\frac{1}{2}$ plus 2	10
Minus 2 plus $1\frac{1}{2}$	15
Minus $1\frac{1}{2}$ plus 1	15
Minus 1 plus $\frac{3}{4}$	15
Minus $\frac{3}{4}$ plus 3/8	25
Minus 3/8 plus 3/16	20

ORGANIZATION

The organization of the quarry and plant personnel is shown in figure 12.

WAGES

Wages are based on a 10-hour day and $5\frac{1}{2}$-day week, as follows:

	Weekly wage
Superintendent	$55.00
Foremen	45.00
Shovel operators	40.00
Cablemen	40.00
Flagmen	12.00
Mechanic and electrician	55.00
Primary drillers	13.75-16.50
Powdermen	20.00
Quarry helpers	8.80
Pumpman	12.00
Crushing plant foreman	40.00
Crushing plant laborers	12.00
Loading foreman	22.00
Loading helpers	11.00
General utility men	12.00

OPERATING COSTS

Table 1. - Summary of costs

Name of quarry: Cayce. Period covered: Jan. 1 to Dec. 2, 1931.

Total stone loaded during period: 251,969 short tons.

Operating costs per dry ton of stone mined

	Labor	Supervision	Power	Fuel	Explosives	Other supplies	Total
Stripping	$0.0115	$0.0009	- - -	- - -	- - -	$0.0080	$0.0204
Mining							
Drilling: Primary .	.0340	.0028	$0.0037	- - -	- - -	.0184	.0589
Secondary	.0486	.0040	.0167	- - -	- - -	.0047	.0740
Blasting	.0062	.0005	- - -	- - -	1/ $0.0806	- - -	.0873
Loading	.0416	.0034	.0037	$0.0154	- - -	.0349	.0990
Transportation	.0228	.0019	.0286	- - -	- - -	.0168	.0701
Miscellaneous	.0041	.0003	.0030	- - -	- - -	.0011	.0085
Crushing: Primary	.0090	.0033	.0034	- - -	- - -	.0062	.0219
Secondary ..	.0018	.0006	.0067	- - -	- - -	.0122	.0213
Tertiary ...	.0004	.0001	.0011	- - -	- - -	.0020	.0036
Screening	.0070	.0025	.0041	- - -	- - -	.0114	.0250
Elevating	.0026	.0009	.0044	- - -	- - -	.0019	.0098
Conveying	.0020	.0007	.0109	- - -	- - -	.0049	.0185
Washing	.0053	.0019	.0026	- - -	- - -	.0029	.0127
Storage	.0053	.0019	.0030	- - -	- - -	.0052	.0154
Miscellaneous plant ..	.0075	.0027	.0019	- - -	- - -	.0145	.0266
Total operating cost..	.2097	.0284	.0938	.0154	.0806	.1451	.5730

1/ Primary blasting, dynamite only $0.0309.
Secondary blasting, do .0176.

Table 2. - Summary of costs in units of labor, power, and supplies

Name of quarry: Cayce. Period covered: Jan. 1 to Dec. 2, 1931.

Total stone loaded during period: 251,969 tons.

	Mining	Crushing	Other	Total
A. Labor (man-hours (per ton of stone):				
Drilling	0.397	- -	- -	- -
Blasting	.021	- -	- -	- -
Loading	.132	- -	- -	- -
Haulage	.052	- -	- -	- -
Miscellaneous	.015	- -	- -	- -
Supervision	.010	- -	- -	- -
Total quarry labor	.627	- -	- -	- -
Average tonnage per man per shift	15.97	- -	- -	- -
B. Power supplies:				
Explosives (pounds per ton): Primary	0.204	- -	- -	- -
Secondary	.133	- -	- -	- -
Total power (kw.-hr. per ton)	- -	- -	- -	7.985
Shovels	[1]0.315	- -	- -	- -
Cableways	2.435	- -	- -	- -
Air compressors	1.422	- -	- -	- -
Drills	.315	- -	- -	- -
Pumps	.255	- -	- -	- -
Crushing	- -	.954	- -	- -
Screening	- -	- -	0.349	- -
Elevating	- -	- -	.375	- -
Conveying	- -	- -	.928	- -
Washing	- -	- -	.221	- -
Drying				
Storage	- -	- -	.255	- -
Miscellaneous	- -	- -	.162	- -
Fuel (tons of coal, per ton of stone)[2]	.0088	- -	- -	- -

[1] One shovel only. Kilowatt-hour used per ton handled by this shovel, 0.59.
[2] One shovel only.

Table 3. - Detailed shovel costs

Shovel no.	Power	Cost per ton loaded [1]				
		Labor	Power	Fuel	Supplies	Total
1	Electric	$0.0360	$0.0069	--------	$0.0490	$0.0919
2	Steam	.0480	--------	$0.0331	.0518	.1329

[1] Costs computed against tons loaded by each shovel.

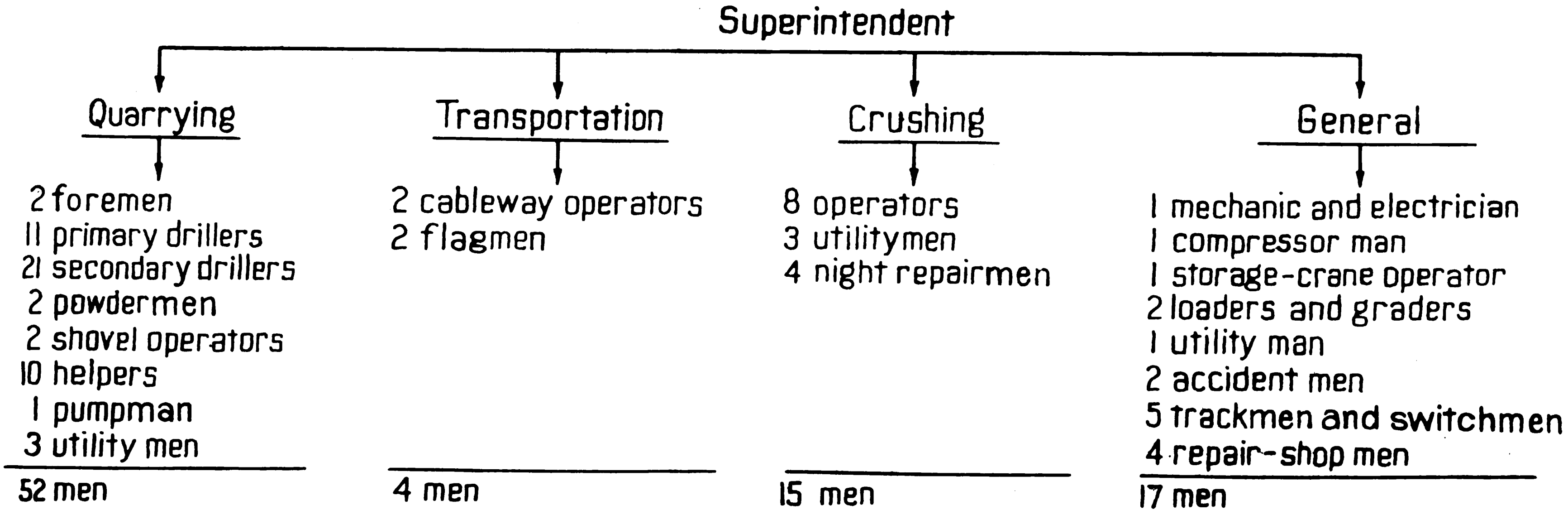


Figure 12.- Organization chart.